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Tests of Lubricating Oils

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TESTS OF LUBRICATING OILS

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THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

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ENTITLED TESTS OF LUBRICATING OILS

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE DEGREE

OF Bachelor of Science in Mechanical Engineering

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TESTS OF LUBRICATING OILS.

I. INTRODUCTION.

There are a number of tests that should be made upon any lubricationg oil in determining its value. These are described in this thesis. The only one of the several tests which was made ~~was~~ the friction test. Special attention was given to this because it is one of the most important to the engineer. Professor J. Goodman, an English mechanical expert, in a paper read before the Manchester Association of Engineers, said: "Out of every ton of coal consumed for engine purposes some 400 to 800 pounds are consumed in overcoming the friction of the working parts of the engine, and further, every machine driven by a motor wastes a large per cent of the remaining power by its own friction. One would not be far short of the mark in saying that from 40% to 80% of the fuel is used in overcoming friction." These are rather startling figures but the following problem illustrates the importance of a good lubricating oil to reduce friction.

If a shaft and flywheel weighing 8000 pounds revolve so that the surface travel of the journal is 300 feet per minute, the horsepower required to run the shaft is 2.909, if the coefficient of journal friction is .04. Taking the cost of a horse power hour as $.00036 it will cost 24 x 2.909 x $.00036 or $.0252 to run the shaft for twenty-four hours. Since this is a cost of about $7.50 per year and there are many such bearings in even a small factory, it will be seen that the total cost of friction amounts to an enormous item. For this reason the lubrication of the

friction parts of machinery should receive more attention than they do at present. Thus it will be seen that the lubricating value of the oil is of prime importance to the engineer and that special attention should be given to this value.

II. THEORY OF LUBRICATION.

1. SLIDING FRICTION. The force which opposes the motion of one particle of matter over another is called FRICTION. This force is omnipresent and opposes all motion under all sorts of conditions at all times. Force is required to push one body over another no matter how smooth they may seem to be. Force is required to cause a body to move through water and force is also required to move the same body through the air. One writer has facetiously described friction as "The highway robber of mechanical energy, levying tribute on all manner of motion, exerting a retarding influence, and requiring power to overcome it". In most mechanical machines this statement is true and only in a comparatively few cases is the presence of friction desirable. In the every day walks of life, however, if it were not for friction, we would often be in trouble. It is the friction between the ground and our shoes that enables us to walk, the friction between the wagon wheels and the earth that enables us to make use of the horse in pulling our load, and the friction between our teeth and food that enables us to masticate it. The problem of the engineer is, however, to do away with as much friction as possible and save the power required to overcome it.

Friction between two rubbing surfaces is due to the fact that they are not perfactly smooth. The most highly polished surface appears rough and uneven under the microscope. In moving over one another, the projections of one interlock with those of the other and force is required to tear them apart. This causes the friction. If it were possible to obtain two perfectly smooth surfaces no force would be required to move one over the other. When a body moves through the water the water becomes engaged in the interstices of it and the same action occurs when the body moves through the air.

2. LAWS OF FRICTION. In 1831, 1832, and 1833 General Arthur Morin, a French engineer, made a number of experiments to determine the laws of friction and from them he deducted the following. These laws relate only to the friction of dry bodies moving one upon the other and are not applicable to a lubricated bearing.

1. Friction varies directly with the pressure of the surfaces.

2. Friction is independent of the areas of the contact surfaces when the pressure and speed remain constant.

3. Friction increases with the roughness of the surfaces and decreases as the surfaces become smoother.

4. Friction is greatest at the beginning of motion.

5. Friction is greater between soft than hard bodies.

The friction of fluids is somewhat different from the friction of solids. When water or any fluid flows through a pipe it is seen that the water nearest the pipe moves very slowly; that a

little farther away, faster, and so on, until the maximum speed is reached farthest away from the sides of the pipe. There is some resistance to motion between the particles, that is, one molecule of the water resists the motion of another over it.

The motion of machine parts over each other is thus seen to require power and the power is turned into heat. If the machine parts were entirely dry a great deal of heat would be generated and the parts would be seriously injured. For this reason, some substance must be placed between the moving parts to prevent their touching. Oil is usually the substance employed. The oil gets between the two moving surfaces, forms a thin film on each, and separates them. Thus, instead of having two dry surfaces in contact, we have two surfaces that are separated and the laws deduced by General Morin do not apply, except in the cases of surfaces under light pressure and running at low speed. The laws of fluid friction would apply more closely here than the laws of dry friction although a combination of both is the one that a well lubricated bearing obeys. Thurston defines fluid friction as "the friction of adjacent bodies of fluid in relative motion, due to the formation of whirls and eddies in the two bodies, the production of which absorbs energy from the moving mass". He gives the following as the laws of fluid friction.

1. Fluid friction is independent of the pressure between the masses in contact.

2. The resistance of fluids is directly proportional to the area resisting it.

3. The resistance is nearly proportional to the square of

the velocity at moderate and high speeds and to the velocity at low speeds.

4. It is independent of the nature of the surfaces against which the stream may flow, but it is dependent to some extent upon the roughness of these surfaces.

5. It is proportional to the density of the fluid and is related in some way to its viscosity.

So far as can be ascertained, no one has yet formulated the definite laws of friction of lubricated bearings but, as indicated above, they probably obey a combination of the laws of fluid and dry friction. They obey the laws of fluid more than the laws of dry friction when well lubricated, but the difficulty of formulating the exact laws for all bearings is at once seen when the trouble of keeping temperature, pressure, speed, oil supply, and quality of oil constant is recognized.

III. LUBRICANTS.

The prevention of this friction loss is accomplished by the use of lubricants. According to modern writers on the subject, these lubricants must possess the following properties:

1. Enough viscosity to keep the surfaces from coming into contact under the maximum pressure which may be applied to them.

2. As much fluidity as is consistent with the foregoing requirements.

3. A great capacity for storing and carrying away heat.

4. A high temperature of decomposition or of evaporation and a low solidification temperature.

5. Freedom from tendency to decompose or oxidize by exposure to the air.

6. Freedom from acidity and from any tendency to corrode the surface to which the oil is applied.

The reasons for demanding that good lubricating oils shall possess all the properties enumerated above are easily found. Since the friction is caused by the rubbing of one surface on another, if the two can be separated the friction between the two will be lessened, if not obliterated. It is impossible to do away with this entirely but if some substance like an oil be introduced between the two surfaces there will be but two films rubbing and the results will be much better than if the two naked pieces of metal were rubbing. Viscosity is the property of adhering to other bodies and cohering to its own particles. A substance may possess one of these qualities without the other but both are needed in a successful lubricant. Mercury possesses great cohesive property but lacks adhesive property and, hence, is not suitable for lubrication purposes. Water, on the other hand, possesses good adhesive properties but not sufficient cohesive power to make it a successful lubricant under ordinary conditions. From this it is seen that the successful lubricant must be viscous.

The lubricants must have fluidity because only fluids have adhesiveness to any marked degree. Graphite and soapstone are the only solid lubricants that are used with any measure of success. They alone are exceptions to this rule and in actual operation do have considerable adhesive power. Greases are not exceptions to

this rule because they must be melted before they perform the services of lubricants. The heat of the bearings melts them and then they act as ordinary oils.

Lubricants must also possess great capacity for storing and carrying away heat. When the bearing is running under any conditions there is bound to be some friction. This friction generates heat and unless it is carried away it will soon become sufficient to injure the bearing. Usually radiation will do away with this heat if the bearing is running under light loads and has sufficient surface area exposed to the atmosphere. When under heavy loads, however, the heat must be absorbed and carried away by some other means and this is required of the lubricants. For this reason they must have a large capacity for heat in order to keep the bearing cool at all times.

Lubricants must be of a suitable composition. If they are liable to decompose at a low temperature injury to the machine will result because the products of decomposition are usually acids and also because these products will not lubricate. As soon as lubrication has stopped heating begins.

The solidification temperature must also be low. If the oils are used in the ordinary gravity feed oil cups, the ones which solidify at a comparatively high temperature stop lubricating as soon as that temperature is reached. It is also inconvenient to have to handle oil which is likely to solidify at a high temperature. Cocoanut oil is a good lubricant in the place where it is manufactured, but in this climate it is worthless because it solidifies at a temperature of 70° F.

The lubricant must be free from any tendency to decompose or to oxidize upon exposure to the air. As soon as the oil begins to oxidize it begins to thicken. This thickening causes a gumming of the bearings and a consequently higher friction. The vegetable oils are very likely to do this and this is one of the main objections to them.

The reason for the last provision is obvious. If the oil contained any acid it would immediately corrode the bearings causing them to become rough and the friction would be considerably higher than under proper conditions. It has been found where acid oils have been used for any length of time that the parts exposed to their action become pitted and extensive repairs are necessary.

IV. TESTS.

In testing oils there are several t ests that ought to be made to determine their relative value. The most important are as follows:

1. Viscosity test.
2. Flash and fire test.
3. Specific gravity test.
4. Cold test.
5. Evaporation test.
6. Oxidation test.
7. Tests for acidity.
8. Detection of soap.

9. Different coefficients of friction under the same conditions.

These will be taken up in the order named.

1. VISCOSITY TEST. For some time it has been known to users of and dealers in oils that the viscosity had a great deal to do with the lubricating value. The reason for demanding viscosity in an oil has been shown before. It is generally thought that the greater the viscosity of an oil, the higher is its lubricating value but it does not follow that a thick, heavy, viscous oil, like a crank case oil, will be better than a lighter one for the lubrication of the spindle. The viscosity of the oil must be adapted to the kind of work it is to do.

All viscosity tests are purely relative and they have not yet been reduced to a standard that is entirely satisfactory. Mr. Wm. M. Davis, of western Pennsylvania, says on this point, "It is to be regretted that there is no standard recognized instrument, or established method of taking the viscosity of fluids, and when one states that a certail oil has a certain viscosity, it conveys no meaning uless the name and make of the instrument, the amount of oil tested, and the temperature are given." In determining the viscosity of oils it is a good plan to take the ordinary oils used on bearings, excepting the heavy crank case oils, at a temperature of 70° F., and again at 120° F., the temperature of a bearing when it is running ordinarily warm. It is sometimes found that two oils having the same temperature have decidedly different values at higher temperatures. For the cylinder and

crank case oils it is best to take the temperatures at 100, 200, and 300 degrees, as these oils are made to withstand higher temperatures.

The viscosity tests are of two entirely different kinds. One determines the viscosity by the time it takes the oil to run out of a tube into a vessel and the other by the resistance it offers to the passage of wooden paddles through it.

One of the simplest instruments for determining the viscosity of an oil by the first method is the Scott viscosimeter. This instrument consists of an oil cup in the bottom of which is a small hole. This hole is opened and closed by a ball fitting into the hole and the ball is lifted by a handle extending up through the top. Surrounding this oil cup is another vessel in which is placed water or oil as the case in hand may demand. This outer chamber is heated bo the required temperature before the experiment is begun. A graduated receptacle is placed under the oil cup. When it has been decided to begin the test the ball is lifted off the hole and the exact time required for 50 c. c. to flow from the oil cup is taken. This time is taken as a measure of the viscosity of the oil. The time required for water to flow from the orifice is taken as unity. Thus, if it takes ten seconds for 50 c. c. of water to flow through the viscosimeter and ninety-five seconds for oil to flow through the viscosity is taken as 95/10 or 9.5.

This method is open to the objection that the density of the oil has an important part to play in forcing the heavy oil through in less time than the lighter one. This objection is entirely

eliminated in the other form of viscosimeter. The Doolittle Torsion Viscosimeter is the best representative of the other form of instrument. From a cross piece a smooth iron cylinder is suspended and above this cylinder is fixed a steel pointer which reads on a scale graduated into degrees. Below the oil chamber, which is stationary, the scale is fastened. The oil to be tested is placed in the oil chamber and heated to the proper temperature. The wire is then twisted through 360 degrees and allowed to resume its former position. The resistance of the oil will be such that the cylinder will not swing back so far as it would if there were no oil in the chamber. The difference in degrees between the first and third swings is taken as the measure of the viscosity of the oil. This is then compared with the viscosity of water as unity and the result is the viscosity of the oil. Thus water shows nine degrees retardation. If water shows sixty-three degrees the viscosity is taken as 63/9 or seven. The results of these tests will give values which, when the conditions of testing the different oils are the same, are of considerable value in determining which is the better oil to use. It would hardly be fair to compare the viscosities of the different oils with each other, the only fair way being to compare the same kinds of oil.

2. FLASH AND FIRE TEST. This test is used to indicate the ability of an oil to withstand heat. Mr. Wm. M. Davis defines the flashing point of an oil as "the temperature to which it must be heated to cause it to give off a vapor which will ignite when mixed with air and exposed to a flame." The fire or burning test

is the temperature at which the oil ignites and continues to burn. Making this test is a very simple matter. A metal cup is mounted on a stand so that a lamp may be passed under it. Hanging from a frame above it is a thermometer which is covered by the oil up a little higher than the bulb. The oil should be heated slowly, not more than ten or fifteen degrees a minute, until a temperature of 100° F., is reached. After this point is reached the flame should be adjusted until the rise in temperature is only about two or three degrees per minute. When testing engine oils the flame should be passed over the surface of the oil two or three times a minute. This flame should be the smallest one obtainable. The flashing point is indicated when a light blue puff of flame is seen when the torch is applied. The burning point is usually from forty to fifty degrees higher and is the point at which the surface of the oil itself ignites. Care should be taken not to remove the termometer from the oil until it has cooled down to a temperature somewhere near the room temperature. A sudden cooling of the thermometer renders it inaccurate. Care should also be taken to see that the thermometers are accurate.

3. SPECIFIC GRAVITY TESTS. There are three general methods in use in making the specific gravity tests; the specific gravity bottle method, the hydrometer method, and the Westphal specific gravity balance. The bottle method is one of the simplest methods and one of the most reliable. The bottle is of thin glass well stoppered with a small hole running through the stopper so that any excess oil runs over and the amount of volume in the bottle

is always the same. The weight of water that the bottle will hold is known. It is then filled with the oil to be tested, the outside carefully wiped off and weighed. The weight of the oil over the weight of the water gives the specific gravity of the oil.

The hydrometer method is the one used by most dealers and users. A hydrometer is calibrated to measure the specific gravity direct when immersed in the oil. Usually two are used, one ranging from .73 to .86 and the other from .86 to 1.0. The former is used for the light distillates and the other for the lubricating oils proper. The Baume hydrometer is one which is generally used but about which there is a great deal of dispute. Just the object that Baume himself had in mind when graduating his hydrometer is not known and there are a number of different scales so that unless all the oils are tested on the same hydrometer the readings are useless. They will not agree for the same oil under the same conditions. For this reason the Baume test should not be used when it can be avoided. All of these tests should be run at a temperature of 60° F.

The Westphal Balance is an accurate method of determining the gravity of the oils. It consists of a balance having a glass bulb whose volume is just five c. c. Thus, when immersed in water it will require the addition of a five gram balance weight. When immersed in lighter liquids, lighter weights are required, and so on, and the beam is graduated to give the specific gravity direct.

This test has been relied upon too much. It is a test that will often tell what an oil is not, but will not tell what it is. Thus, in testing sperm oil, the specific gravity may be shown to be .88, which is correct, but in order to identify it positively other tests must be made. If, however, the gravity is found to be .87 the oil may at once be rejected as not a sperm oil. It is by no means an identification test. The gravities of different oils are so nearly the same that they may be mixed in the proper proportion and the gravity of any oil be imitated perfectly.

4. COLD TEST. The cold test is the one which will give us the point at which transparent oil begins to become opaque and at which a dense and viscous oil begins to flow after being frozen. This test is of no value whatever as an index to the lubricating value of the oil, but if the oil is to be exposed to the weather, it is highly important that it be of such a nature that it will not congeal at temperatures to which it is to be exposed. To make this test, immerse the bottles containing the oils in a mixture of cracked ice and salt and with properly calibrated thermometers note the temperatures at which the oils congeal.

5. EVAPORATION TEST. The evaporation test is one which usually gives the commercial loss attendant upon exposing the oil to the atmosphere. Oils must be bought and paid for by the gallon, hence, it follows that when the oil evaporates there is less of it to use and also that its density is increased and this in turn increases its frictional effect. In the case of textile mills the increase of frictional effect is the injurious one. The

spindles run in a bath of oil and, if there is more friction than there should be, their speed is cut down and the bobbins to which they are attached do not run as they should.

The test is made as follows. A small quantity of oil is poured into a shallow dish, weighed on a chemist's fine balance, and exposed for ten hours to a temperature of 140 to 150° F. At the end of this time it is weighed again and the per centage of evaporation will be the difference in weight divided by the original weight.

6. OXIDATION TEST. For most machinery it is essential that the oil be of a character that will not gum the bearing. This gumming increases the frictional loads immensely. Three methods are in vogue to determine this value. One method, which is somewhat crude and of only comparative value is to place drops of oil to be tested on panes of glass and to note the times taken by the drops before they are arrested by the oxidation as they travel down the panes. Still another method is to smear the oils evenly over panes of glass and expose them to the air for the same period of time varying from ten hours to two weeks. The relative oxidation will be indicated by the stickiness of the oils and their tendency to cling to the finger nail when touched by it. Another method, and perhaps the most accurate of all, is as follows: Place the oils in shallow vessels being sure that all the moisture has been removed from them, and then place the vessels with the oils into a water bath where thy are to remain for ten or twenty-four hours at a temperature of 212° F. The increase of weight at

the end of the time will give the weight of oxygen absorbed. For records which are to be filed away this last method is much to be preferred over the others as no records can be made in the other two, owing to the absence of a standard.

7. ACIDITY TEST. Acidity in oils is always bad because of the manner in which the acids attack the bearing metals and corrode them. They also form metallic soaps in the bearings and increase the friction. They are caused by the decomposition of the oils and the liberation of the free fatty acids. Pure refined mineral oils do not have this objectionable feature and are to be preferred for this reason. Almost all animal and vegetable oils possess it to an extent. The test is made as follows: Take two ounces of alcohol and heat it to about 100° F., add a few drops of alcoholic solution of phenolphthalein. Fill a burette to the top of the graduation with the caustic potash solution (one-tenth normal K.O.H.); then add solution, drop by drop, to the alcohol until it assumes a pink tint. Add ten c. c. of the oil to the alcohol, refill the burette with the potash solution and add the latter until the mixture of oil and alcohol maintains a pink color after a thorough shaking. Read off the number of c. c. of potash solution used and this amount divided by two gives the per cent of free acid. It is obvious that the lower this per cent is, the better is the oil for lubricating purposes.

8. DECTECTION OF SOAP. Oil is often thickened and its viscosity thereby increased by the addition of "oil pulp", "oil thickener", and "white gelatin". These substances are usually

oleates of aluminum, or other bases may be present. The objection to this adulteration is that it causes the oil to thicken more readily when cold, in other words, raises its cold test, and the soap is precipitated by contact with water or steam. This precipitate causes the bearing to clog more readily and the consequent increase of friction. The test is made as follows:

Five or ten drops of the oil to be tested are dissolved in about five c. c. of 86 degrees gasoline or ether, and about fifteen drops of the saturated solution of metaphosphoric acid in absolute alcohol added, shaken and allowed to stand; the formation of a floculent precipitate indicates the presence of soap. An idea of the kind of soap can often be gained by adding an alcoholic solution of P_tCl_4. If the precipitate becomes crystalline it is a potash soap; if it dissolves, soda or magnesia; if unchanged, alumina or iron.

9. DETERMINATION OF COEFFICIENTS OF FRICTION UNDER THE SAME CONDITIONS. The determination of the coefficient of friction under the same conditions is one of the most important of the above mentioned tests. It is purely mechanical in its nature, and in order to be accurate, must be made upon specially designed oil testing machines. These tests are the only ones of the number mentioned which were actually performed in this thesis. They were performed in the Mechanical Engineering Laboratory of the University of Illinois during the months of April and May, 1907. The purpose of these tests was to prove by actual trial which of the oils of their respective kinds now

used by the University were the best for lubricating purposes. The oils tested were cylinder, crank case, and engine oils and were products of the Standard Oil Company and the Viscosity Oil Company. The commercial names of the oils tested from the Standard Oil Company were Renown Engine Oil, Capital Cylinder Oil, and Vacuum Crank Case Oil. From the Viscosity Company, the oils tested were Filtered Spindle Engine Oil, Watt Cylinder Oil, and Extra Crank Case Oil. Another purpose of the experiment was to investigate the number of drops required for a flooded bearing and the difference in power consumed by friction when the bearing was running flooded and when it was running with less lubrication.

The oil testing machine used was made by the Central Laboratory Supply Company, of Lafayette, Indiana. The parts of the machine are as follows: (See photograph on page 20.)

A. A frame to support the parts.

B. The yoke at the end of which the load is carried.

C. The bearing on which the oil is to be tested.

D-D. Two bearings to support the spindle that revolves in the yoke.

E. A 110 volt single phase, three horse power, alternating current motor which drives the spindle.

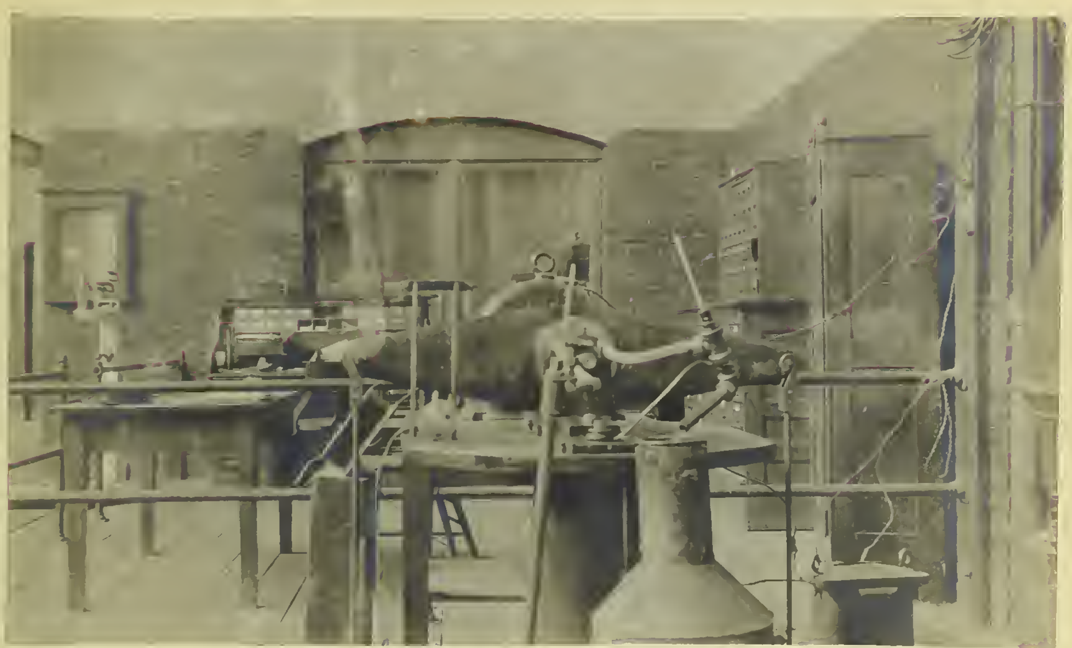
F. Scales on which the tendency of the yoke to revolve is measured.

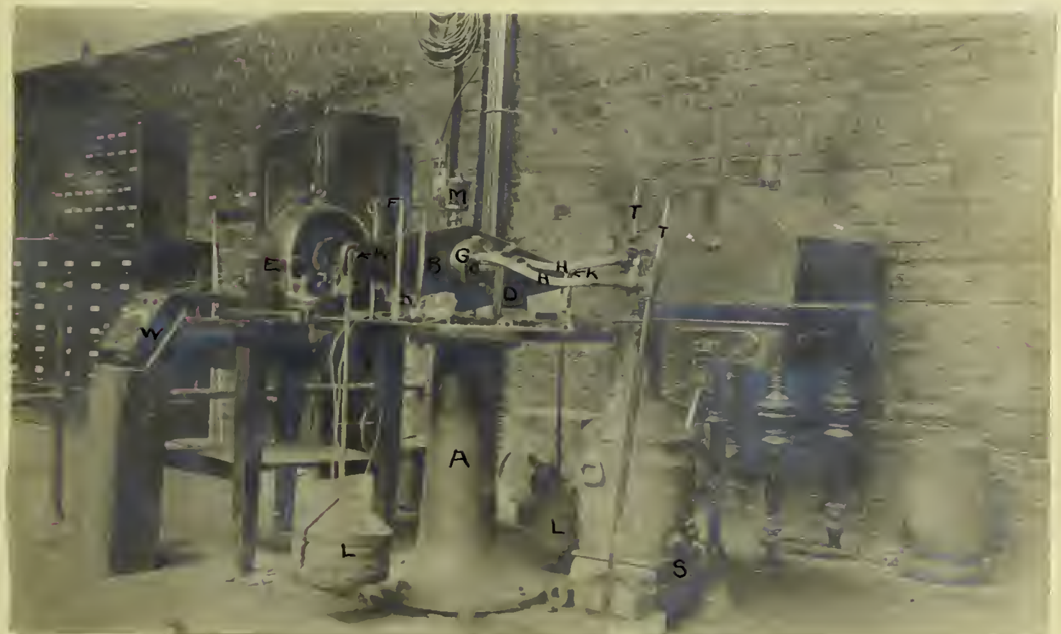
G. Cast iron housing which fits into B.

L-L. Load.

K-K. Knife edges.

W. Wattmeter used to measure power used by motor.





OIL TESTING MACHINE.

M. The glass oil cup arranged so that oil may be dropped into the bearing at a uniform rate.

The cast iron housing which fits into the beam is cored hollow and water is run through the tubes H-H to keep the bearing cool. This water is weighed on the scales S and its temperature taken on entering and leaving by Fahrenheit thermometers at T-T.

This machine is so designed as to give the pull due to friction in the bearing without any interposed mechanism. This is accomplished by placing the bearing, to which the oil to be tested is applied, in the yoke. This bearing is supported by a spindle which passes through it and the friction due to revolving the spindle inside of the bearing gives the yoke a tendency to revolve. The load is given by hanging weights on the rods that are suspended from the knife edges K-K. These knife edges are made to be in a straight line passing through the center of the bearing and the yoke is made stiff enough so that there is no appreciable bend under any load that the bearing will stand.

The tests on the different oils were run with the load and speed remaining constant, the only variation being the number of drops of oil supplied to the bearing per minute. Each test lasted two hours, the spindle being run in one direction for an hour and then reversed, the oil drop remaining the same both ways. When a new oil was placed in the cup, the four tests, namely on six, four, two, and one drops per minute, were run before another oil was tried. Before a new oil was introduced the oil cup was emptied and cleaned with gasoline, the spindle was removed and

both it and the bearing cleaned and examined. Next the machine was run with gasoline as a lubricant for a few minutes to remove all traces of oil in the oil passages. Before any readings were taken, the spindle was run for sometime under load to let the bearing warm and allow conditions to become constant. The oils were tested in the following order: Renown Engine, Filtered Spindle Engine, Vacuum Crank Case, Capital Cylinder, Watt Cylinder, and Extra Crank Case. All oils were secured from Mr. J. A. Morrow to make sure no mistake was made concerning the oils supplied.

The pull due to friction is found as follows: A load is placed on the yoke opposite the scales that is slightly greater than that on the other end and the tendency of the yoke to revolve is met by the scales F. The motor is then started which revolves the spindle in one direction and the pull on the scales is measured. After the operation has been continued long enough to give constant results the spindle is reversed. As there is excess load on one side of the yoke the revolution of the yoke in one direction will tend to increase this load while the revolution in the other tends to diminish it. Half of the difference is the load due to friction. The distance from the center of the spindle to the surface being tested is the arm of the load, while the distance from the center to the point at which the scale is attached is the arm of the scale. A more thorough discussion of this will be given in the calculation or results.

OIL TEST.

COMPARATIVE LUBRICATION.

TOTAL LOAD ON BEARING 275. LBS. PR. SQ. IN. 26.

DATE APRIL 24, 1907 TEST NO. 1

READ. NO.	TIME	R.P.M.	OIL DROP PER MIN.	WATER TEMP. IN.	OUT	WT. WATER LBS.	B.T.U.	MOTOR K.W.	FRICTION PULL LBS.
1.	1:15	1792	7	77	85			.47	4.75
2	1:20	1802	7	86	87	6.81	30.6	.46	5.00
3.	1:25	1814	7	86	89	7.06	14.1	.45	5.00
4.	1:30	1798	7	84	89	6.62	36.4	.44	5.00
5.	1:35	1822	7	82	87	6.07	30.3	.43	5.00
6.	1:40	1800	7	.81	86	6.44	29.0	.43	5.00
7.	1:45	1805	7	80	85	6.56	29.8	.42	5.00
8.	1:50	1815	7	80	85	6.75	33.7	.42	5.00
9.	1:55	1804	7	80	84	5.94	26.7	.42	5.00
10	2:00	1796	7	79	84	6.00	27.0	.43	5.00
11	2:05	1795	7	79	84	5.87	29.4	.43	5.00
12.	2:10	1832	6	79	84	7.82	39.1	.43	5.00
13	2:15	1795	6	79	84	5.25	26.2	.42	5.00
TOTAL							352.3		
AV.		1800	7	80.9	85.5			.43	5.00
1	2:35	1790	7	71	78			.54	9.50
2.	2:40	1794	7	72	79	4.44	31.1	.54	9.50
3	2:45	1796	6	72	82	3.50	35.0	.54	9.50
4	2:50	1794	6	73	84	3.62	39.8	.50	9.25
5	2:55	1796	7	74	85	3.50	38.5	.48	9.25
6	3:00	1780	7	75	86	4.00	44.0	.48	9.37
7	3.05	1793	7	75	86	2.75	30.2	.48	9.38
8	3.10	1796	7	76	86	3.00	30.0	.47	9.37
9	3.15	1776	6	75	87	4.69	55.2	.48	9.38
10	3.20	1785	7	76	87	3.25	35.7	.48	9.37
11	3.25	1794	7	76	87	3.88	42.6	.48	9.38
12	3.30	1794	7	76	87	3.89	42.6	.48	9.37
13	3.35	1786	7	76	87	3.38	37.2	.48	9.38
TOTAL							461.9		
AV.		1785	7	74.4	85			.494	9.4

RENOWN ENGINE OIL COEFFICIENT OF FRICTION .0366

OIL TEST.

COMPARATIVE LUBRICATION.

TOTAL LOAD ON BEARING 275. LBS. PR SQ. IN. 20.

DATE APRIL 27-29, 1907 TEST NO. 2

READ NO.	TIME	R.P.M.	OIL DROP PER MIN.	WATER TEMP. IN.	WATER TEMP. OUT	WT. WATER LBS.	B.T.U.	MOTOR K.W.	FRICTION PULL LBS.
1	4:10	1830	4	76	87			.60	3.5
2	4:15	1840	4	73	86	5.19	62.2	.64	3.5
3	4:20	1812	3	77	83	4.94	47.8	.64	3.2
4	4:25	1827	4	77	89	4.69	51.6	.65	3.0
5	4:30	1810	4	77	88	3.62	50.8	.55	4.5
6	4:35	1815	3	79	89	6.62	69.5	.50	4.5
7	4:40	1800	4	79	89	4.62	43.9	.50	4.5
8	4:45	1800	4	79	89	3.00	30.0	.52	4.5
9	4:50	1840	3	79	89	4.38	43.7	.53	4.5
10	4:55	1815	4	79	89	3.81	38.2	.52	4.5
11	5:00	1820	4	79	89	3.31	33.1	.52	4.8
12	5:05	1820	4	78	89	4.38	46.0	.51	4.7
13	5:10	1850	4	78	89	3.63	39.9	.50	4.8
TOTAL							554.7		
AV.		1820	4	77.5	88			.55	4.3
1	1:45	1755	4	71	85			.60	10.2
2	1:50	1700	4	70	88	2.19	35.0	.60	10.
3	1:55	1700	4	70	89	1.88	34.7	.55	10.
4	2:00	1800	4	70	91	1.62	32.5	.55	10.
5	2:05	1770	4	70	91	2.18	45.9	.55	10.
6	2:10	1770	4	70	91	2.94	61.6	.55	10.
7	2:15	1710	4	70	91	.63	13.1	.55	10.
8	2:20	1716	4	70	91	2.19	45.9	.54	10.
9	2:25	1740	4	70	91	1.44	13.3	.54	10.
10	2:30	1720	4	70	91	1.13	54.0	.53	9.8
11	2:35	1725	4	70	91	2.56	53.9	.54	9.7
12	2:40	1740	4	70	91	2.06	43.4	.56	9.8
13	2:45	1730	4	70	91	1.56	32.8	.56	9.7
TOTAL							466.1		
AV.		1730	4	70	89			.564	9.91

RENOWN ENGINE OIL. COEFFICIENT OF FRICTION .0467

Oil Test.

Comparative Lubrication.

Total Load on Bearing 275. Lbs. pr. Sq. In. 20.

Date April 29, 1907 Test No. 3

Read. No.	Time	R.P.M.	Oil Drop Per Min.	Water Temp. In.	Water Temp. Out	Wt. Water Lbs.	B.T.U	Motor K.W.	Friction Pull Lbs.
1.	3:15	1680	2	72	90			.58	10.5
2	3:20	1670	2	72	93	2.87	60.3	.64	10.7
3.	3:25	1626	2	72	89	3.37	57.1	.66	10.8
4.	3:30	1622	2	68	90	3.00	66.0	.60	10.7
5.	3:35	1730	2	72	90	2.00	36.0	.62	10.6
6.	3:40	1666	2	72	90	4.00	72.0	.67	10.8
7.	3:45	1680	2	72	90	3.50	63.0	.70	10.7
8	3:50	1700	2	72	93	2.44	51.3	.64	10.8
9	3:55	1700	2	72	93	3.56	75.2	.65	10.7
10	4:00	1620	2	73	92	2.44	46.4	.65	10.7
11	4:05	1650	2	73	93	3.25	65.0	.65	10.8
12	4:10	1700	2	73	93	3.25	65.0	.66	10.7
13	4:15	1700	2	73	93	2.68	53.6	.66	10.8
Total							710.9		
Av.		1680	2	72	91.4			.644	10.7
1	4:25	1704	2	73	95			1.	1.25
2.	4:30	1640	2	73	99	2:75	66.	1.	0.
3		Would not run. Bearing Dry.							
4		Insufficient lubrication.							
5									
6									
7									
8									
9									
10									
11									
12									
13									
Total									
Av.									

Renown Engine Oil. Coefficient of Friction

OIL TEST.

COMPARATIVE LUBRICATION.

TOTAL LOAD ON BEARING 275. LBS. PR SQ. IN. 20.

DATE APRIL 26. 1907 TEST NO. 1

READ NO.	TIME	R.P.M.	OIL DROP PER MIN	WATER TEMP. IN.	WATER TEMP. OUT	WT WATER LBS.	B.T.U.	MOTOR K.W.	FRICTION PULL LBS
1.	2:10	1740	7	77	87	[illegible]	[illegible]	.54	4.7
2	2:15	1760	8	76	88	3.37	36.0	.52	4.9
3.	2:20	1790	8	75	86	4.87	34.4	.58	4.7
4.	2:25	1800	7	75	86	3.25	56.0	.56	4.9
5	2:30	1760	7	74	85	5.19	41.3	.54	5.0
6	2:35	1766	8	74	84	3.94	37.8	.54	5.0
7	2:40	1785	7	72	84	3.44	42.5	.54	5.0
8	2:45	1791	6	72	83	3.69	44.0	.52	5.0
9	2:50	1770	6	73	83	4.19	56.0	.52	5.0
10	2:55	1800	8	73	83	4.06	40.6	.52	5.0
11	3:00	1812	7	73	83	5.00	50.0	.51	5.1
12	3:05	1740	7	73	83	3.38	33.7	.54	5.3
13	3:10	1800	7	73	83	4.13	41.2	.54	5.0
TOTAL							514.1		
AV		1780	7	73.7	84.5			.54	5.0
1	3:20	1780	7	73	83.			.56	9.5
2	3:25	1800	7	73	83.	4.19	41.87	.54	9.8
3	3:30	1830	6	73	83.	4.56	45.2	.54	10.0
4	3:35	1790	6	73	84.	3.63	36.2	.54	10.0
5	3:40	1790	7	73	84.	4.81	50.6	.54	10:0
6	3:45	1820	7	73	83.	4.88	51.2	.55	10.0
7	3:50	1800	7	73	83.	4.12	43.4	.52	10.0
8	3:55	1660	7	73	83.	4.50	45.0	.55	9.7
9	4:00	1780	8	73	83.	3.62	36.2	.55	9.8
10	4:05	1800	7	73	83.	3.75	41.2	.50	9.5
11	4:10	1670	8	73	83.	5.19	51.6	.58	9.7
12	4:15	1800	7	73	83.	3.50	35.0	.53	9.8
13	4:20	1820	7	73	83.	3.94	39.4	.50	9.8
TOTAL							517.3		
AV		1790	7	73	83			.537	9.8

FILTERED SPINDLE ENGINE OIL COEFFICIENT OF FRICTION .0399

OIL TEST.

COMPARATIVE LUBRICATION.

TOTAL LOAD ON BEARING 275. LBS. PR. SQ. IN. 20.

DATE APRIL 27, 1907 TEST NO. 2

READ. NO.	TIME	R.P.M.	OIL DROP PER MIN.	WATER TEMP. IN.	WATER TEMP. OUT	WT. WATER LBS.	B.T.U.	MOTOR K.W.	FRICTION PULL LBS.
1.	8:35	1776	4	70	73			.50	9
2.	8:40	1800	4	71	75	6.44	15.3	.50	9
3.	8:45	1820	4	70	75	6.12	27.6	.52	9
4.	8:50	1800	4	69	75	6.44	35.0	.52	9
5.	8:55	1806	4	67	76	4.56	34.2	.50	9
6.	9:00	1780	4	67	76	3.50	31.5	.50	9
7.	9:05	1890	4	67	76	4.31	38.8	.48	9
8.	9:10	1780	4	67	75	3.62	30.8	.48	9
9.	9:15	1800	4	67	75	4.25	34.0	.48	9
10.	9:20	1780	4	67	76	3.50	39.8	.50	9
11.	9:25	1740	4	67	76	4.81	43.4	.48	9
12.	9:30	1760	4	67	76	3.69	33.2	.48	9
13.	9:35	1810	4	67	76	3.06	27.6	.48	9
TOTAL							381.2		
AV.		1810	4	67.7	75.3			.494	9
1.	9:45	1760	4	68	79			.56	4
2.	9:50	1800	5	67	80	4.81	56.4	.58	4
3.	9:55	1840	6	66	80	2.94	35.0	.56	4.2
4	10:00	1780	4	67	80	3.37	40.5	.57	4.3
5	10:05	1800	4	67	79	1.69	20.6	.58	4.2
6	10:10	1790	4	66	79	5.63	67.5	.57	4.3
7	10:15	1800	4	66	79	3.69	44.3	.58	4.2
8	10:20	1800	4	66	79	3.44	41.6	.58	4.3
9	10:25	1800	4	66	79	3.94	47.2	.52	4.2
10	10:30	1790	4	67	79	3.00	36.0	.54	4.3
11	10:35	1800	4	66	80	3.56	46.4	.53	4.2
12	10:40	1800	4	66	80	3.37	47.2	.54	4.3
13	10:45	1780	4	66	80	2.94	41.	.53	4.2
TOTAL							523.7		
AV.		1795	4.2	66.4	79.5			.557	4.25

FILTERED SPINDLE ENGINE OIL. COEFFICIENT OF FRICTION .0437

OIL TEST.

COMPARATIVE LUBRICATION.

TOTAL LOAD ON BEARING 275. LBS. PR. SQ. IN. 20.

DATE APRIL 27, 1907 TEST NO. 3

READ. NO.	TIME	R.P.M.	OIL DROP PER MIN.	WATER TEMP. IN.	WATER TEMP. OUT	WT. WATER LBS.	B.T.U.	MOTOR K.W.	FRICTION PULL LBS
1.	11:00	1750	2	66	76			.56	4.1
2.	11:05	1800	2	66	76	5.81	58.17	.56	4.
3.	11:10	1820	2	67	77	4.81	48.17	.55	4.1
4.	11:15	1840	2	67	77	5.69	56.81	.56	4.1
5.	11:20	1840	2	67	77	4.94	49.37	.55	4.
6.	11:25	1800	2	67	77	5.69	49.37	.55	4.2
7.	11:30	1780	2	67	77	4.44	56.81	.56	4.1
8.	11:35	1800	2	67	77	6.00	43.75	.56	4.1
9.	11:40	1800	2	67	77	5.44	60.00	.56	4.1
10.	11:45	1820	2	67	77	5.82	54.37	.56	4.2
11.	11:50	1820	2	67	77	5.88	58.75	.55	4.1
12.	11:55	1800	2	67	77	5.81	58.12	.55	4.1
13.	12:00	1800	2	67	77	5.75	57.50	.56	4.2
TOTAL							649.0		
AV.		1800	2	67	77			.556	4.1
1.	12:10	1800	2	67	76			.55	9.5
2.	12:15	1860	2	68	76	6.69	56.7	.56	9.5
3.	12:20	1844	2	67	75	7.00	59.5	.52	9.5
4	12:25	1808	2	67	75	2.06	17.5	.52	9.5
5	12:30	1840	2	67	76	12.00	96.0	.54	9.5
6	12:35	1810	2	67	76	8.00	68.0	.54	9.5
7	12:40	1806	2	67	78	7.44	47.0	.55	9.5
8	12:45	1830	2	66	82	3.94	41.3	.55	9.5
9	12:50	1827	2	67	84	4.25	37.4	.52	9.5
10	12:55	1804	2	68	85	3.00	46.5	.54	9.5
11	1:00	1820	2	68	78	2.00	34.0	.52	9.5
12	1:05	1860	2	68	77	4.06	69.0	.55	9.5
13	1:10	1790	2	68	76	3.87	52.4	.54	9.5
TOTAL							625.3		
AV.		1817	2	67.3	77.5			.538	9.5

FILTERED SPINDLE ENGINE OIL COEFFICIENT OF FRICTION .0445

Oil Test.

Comparative Lubrication.

Total Load on Bearing 275. Lbs. pr. Sq. In. 20.

Date April 27, 1907 Test No. 4

Read. No.	Time	R.P.M.	Oil Drop per Min.	Water Temp. In.	Water Temp. Out	Wt. Water Lbs.	B.T.U.	Motor K.W.	Friction Pull Lbs.
1.	1:35	1830	1	68	79			.52	9.6
2.	1:40	1740	1	68	80	4.0	46.0	.54	9.5
3.	1:45	1800	1	68	81	4.0	50.0	.56	9.8
4.	1:50	1860	1	68	81	4.0	52.0	.58	10.0
5.	1:55	1800	1	68	82	4.0	54.0	.58	9.7
6.	2:00	1820	1	69	82	3.5	47.3	.55	9.5
7.	2:05	1782	1	69	82	3.8	49.6	.55	9.6
8.	2:10	1830	1	69	82	4.8	62.6	.55	9.5
9.	2:15	1800	1	70	82	2.9	35.9	.53	9.7
10.	2:20	1818	1	70	83	3.7	46.7	.55	9.5
11.	2:25	1900	1	71	83	3.5	46.4	.54	9.7
12.	2:30	1790	1	70	84	3.5	48.2	.55	9.8
13.	2:35	1790	1	71	84	3.6	50.8	.54	9.5
Total							590.4		
Av.		1810	1	69	81.8			.549	9.65
1.	2:45	1800	1	71	84			.63	3.5
2.	2:50	1780	1	72	88	2.2	31.7	.68	2.6
3.	2:55	1810	1	73	86	5.5	80.6	.60	3.7
4	3:00	1800	1	74	86	5.1	63.2	.60	3.2
5	3:05	1810	1	75	86	5.3	60.5	.64	3.5
6	3:10	1790	1	76	87	5.4	59.1	.65	3.5
7	3:15	1810	1	76	88	5.3	61.2	.60	3.8
8	3:20	1780	1	77	89	4.8	37.8	.55	4.0
9	3:25	1810	1	78	89	4.2	48.1	.58	4.0
10	3:30	1792	1	78	90	3.6	41.8	.58	4.0
11	3:35	1824	1	78	90	4.5	54.7	.60	3.5
12	3:40	1800	1	78	91	4.0	50.0	.60	3.7
13	3:45	1854	1	78	91	2.8	36.5	.60	3.5
Total							625.2		
Av.		1805	1	75.7	88			.606	3.58

Filtered Spindle Engine Oil. Coefficient of Friction .0505.

OIL TEST.

COMPARATIVE LUBRICATION.

TOTAL LOAD ON BEARING 275. LBS. PR. SQ. IN. 20.

DATE APRIL 30, 1907 TEST NO. 1

READ. NO.	TIME	R.P.M.	OIL DROP PER MIN.	WATER TEMP. IN.	WATER TEMP. OUT	WT. WATER LBS.	B.T.U.	MOTOR K.W.	FRICTION PULL LBS
1.	1:55	1820	5	59	74			.91	1.5
2.	2:00	1770	5	59	73	9.0	130.5	1.2	1.4
3.	2:05	1800	5	59	71	7.9	102.2	.8	2.5
4.	2:10	1800	4	59	75	8.0	112.	.8	2.5
5.	2:15	1810	6	59	76	6.0	97.7	.85	2.0
6.	2:20	1790	6	59	76	11.5	195.5	.84	2.2
7.	2:25	1790	6	59	70	6.0	84.	.8	2.3
8	2:30	1776	6	59	69	11.5	115.5	.8	2.2
9.	2:35	1806	6	59	69	7.0	70.	.8	2.3
10.	2:40	1824	6	59	69	12.9	120.	.8	2.2
11.	2:45	1800	6	59	69	8.6	86.7	.8	2.3
12.	2:50	1800	6	59	70	8.9	93.8	.78	2.5
13.	2:55	1780	6	59	71	7.0	80.5	.8	2.5
TOTAL							1225.5		
AV.		1797	6	59	71.6			.846	2.2
1.	3:00	1800	6	59	79			.7	10.2
2.	3:05	1790	6	60	80	4.7	93.9	.7	10.2
3.	3:10	1810	7	59	80	3.8	78.0	.7	10.0
4	3:15	1800	10	59	80	4.1	85.4	.7	10.0
5	3:20	1810	6	59	80	3.4	72.0	.7	10.2
6	3:25	1780	6	60	80	3.6	70.5	.7	10.0
7	3:30	1800	5	60	80	3.5	71.3	.7	10.0
8	3:35	1810	6	61	81	4.9	98.6	.7	11.0
9	3:40	1800	6	62	81	3.9	75.5	.7	11.2
10	3:45	1810	6	62	82	4.0	78.0	.7	11.2
11	3:50	1800	6	62	82	3.1	61.4	.7	11.0
12	3:55	1810	6	62	84	3.5	73.5	.7	11.0
13	4:00	1800	6	62	87	2.1	50.6	.7	10.8
TOTAL							908.7		
AV.		1800	6.2	60.5	81			.7	10.5

VACUUM CRANK CASE OIL. COEFFICIENT OF FRICTION .069.

OIL TEST.

COMPARATIVE LUBRICATION.

TOTAL LOAD ON BEARING 275. LBS. PR SQ. IN. 20.

DATE MAY 1, 1907 TEST NO. 2

READ NO.	TIME	R.P.M.	OIL DROP PER MIN	WATER TEMP. IN.	WATER TEMP. OUT	WT WATER LBS.	B.T.U.	MOTOR K.W.	FRICTION PULL LBS
1.	1:30	1840	4	77	85			.70	11
2	1:35	1860	4	77	88	6.7	63.5	.71	11
3.	1:40	1840	4	78	92	4.4	64.7	.71	11
4.	1:45	1840	4	82	96	4.3	61.8	.70	11
5	1:50	1800	4	79	97	4.1	66.0	.72	11
6	1:55	1840	4	76	96	6.1	114.0	.72	11
7	2:00	1810	4	74	94	4.2	86.2	.71	11
8	2:05	1830	4	72	93	4.1	83.2	.73	11
9	2:10	1860	4	72	92	4.0	80.5	.72	11
10	2:15	1820	4	71	92	4.2	80.7	.72	11
11	2:20	1840	4	72	92	3.7	78.0	.72	11
12	2:25	1840	4	72	92	4.4	87.5	.73	11
13	2:30	1820	4	66	92	4.5	105.0	.71	11
TOTAL							963.1		
AV.		1833	4	74	92			.715	11
1	2:40	1840	4	61	86			.77	2.5
2	2:45	1850	4	61	89	2.4	60.5	.76	2.7
3	2:50	1836	4	56	91	2.7	86.8	.80	2.5
4	2:55	1820	4	62	93	2.6	86.7	.76	2.2
5	3:00	1830	4	62	96	2.5	81.2	.76	2.5
6	3:05	1850	4	62	97	2.7	93.0	.78	2.5
7	3:10	1830	4	61	86	5.8	174.1	.80	2.5
8	3:15	1810	4	61	85	4.2	102.1	.80	2.5
9	3:20	1830	4	60	79	7.8	168.0	.80	2.5
10	3:25	1820	4	60	79	5.7	109.1	.83	2.4
11	3:30	1830	4	60	79	5.5	109.1	.79	2.5
12	3:35	1800	4	60	79	5.7	105.6	.80	2.5
13	3:40	1800	4	60	80	4.3	85.0	.84	2.5
TOTAL							1261.0		
AV.		1830	4	60.5	85.3			.791	2.5

VACUUM CRANK CASE OIL. COEFFICIENT OF FRICTION .0707

OIL TEST.

COMPARATIVE LUBRICATION.

TOTAL LOAD ON BEARING 275. LBS. PR. SQ. IN. 20.

DATE MAY 1, 1907 TEST NO. 3

READ. NO.	TIME	R.P.M.	OIL DROP PER MIN.	WATER TEMP. IN.	WATER TEMP. OUT	WT. WATER LBS.	B.T.U.	MOTOR K.W.	FRICTION PULL LBS.
1.	3:55	1800	2	61	81			.86	2.2
2	4:00	1800	2	61	78	8.2	139.5	.90	2.3
3.	4:05	1810	2	61	79	7.1	127.9	1.30	2.2
4.	4:10	1800	2	61	79	7.3	131.2	.90	2.0
5.	4:15	1820	2	63	79	8.3	133.0	1.10	1.5
6.	4:20	1810	2	65	83	8.0	144.0	1.10	1.0
7	4:25	1800	2	65	85	6.6	132.0	1.00	1.0
8	4:30	1810	2	66	86	6.7	134.0	1.00	.8
9.	4:35	1800	2	66	87	6.7	141.0	1.10	.8
10	4:40	1800	2	67	86	6.6	125.5	1.00	1.0
11	4:45	1800	2	67	86	6.3	120.0	.80	1.5
12	4:50	1820	2	67	86	5.5	104.0	.80	2.0
13	4:55	1800	2	68	86	5.4	97.5	.86	1.3
TOTAL							1529.6		
AV.		1805	2	64.4	83			.98	1.44
1	5:00	1790	2	68	85			.84	11.7
2.	5:05	1810	2	68	85	5.7	97.0	.84	11.8
3	5:10	1820	2	67	85	4.3	77.5	.81	11.5
4	5:15	1810	2	68	86	5.5	99.0	.80	11.3
5	5:20	1800	2	68	86	5.5	99.0	.74	11.0
6	5:25	1780	2	68	85	5.1	86.7	.71	11.2
7	5:30	1800	2	69	84	5.4	81.0	.71	11.3
8	5:35	1800	2	70	85	5.5	82.5	.74	11.3
9	5:40	1810	2	70	85	5.3	79.5	.75	11.0
10	5:45	1800	2	70	85	5.6	84.0	.71	11.2
11	5:50	1810	2	70	85	5.3	79.5	.71	11.0
12	5:55	1800	2	70	85	5.4	81.0	.71	11.3
13	6:00	1800	2	70	85	5.5	82.5	.72	11.2
TOTAL							1029.2		
AV.		1800	2	69	85			.75	11.28

VACUUM CRANK CASE OIL. COEFFICIENT OF FRICTION .0816

OIL TEST.

COMPARATIVE LUBRICATION.

TOTAL LOAD ON BEARING 275. LBS. PR. SQ. IN. 20.

DATE MAY 2, 1907 TEST NO. 4

READ. NO.	TIME	R.P.M.	OIL DROP PER MIN.	WATER TEMP. IN.	OUT	WT. WATER LBS.	B.T.U.	MOTOR K.W.	FRICTION PULL LBS.
1.	9:40	1800	1	61	82			.80	11.9
2	9:45	1800	1	64	81	4.7	80.0	.81	11.7
3.	9:50	1856	1	66	84	3.8	68.5	.90	12.0
4.	9:55	1830	1	68	88	3.4	68.0	.85	11.9
5.	10:00	1806	1	69	91	3.0	66.0	.80	12.0
6.	10:05	1812	1	70	93	3.0	69.0	.82	11.9
7.	10:10	1850	1	71	94	4.0	92.2	.90	12.0
8.	10:15	1770	1	69	95	3.8	99.0	.82	11.7
9.	10:20	1810	1.5	76	97	3.0	63.0	.83	11.8
10	10:25	1790	1.5	71	98	3.5	59.5	.81	11.8
11.	10:30	1790	1.	71	99	3.0	84.0	.86	11.9
12.	10:35	1820	1.	75	99	3.4	81.7	.85	12.0
13	10:40	1860	1.	74	99	3.3	82.5	.86	12.0
TOTAL							913.4		
AV.		1815	1.01	69.5	92.5			.84	11.53
1.	10:50	1840	.5	71	102.	3		.90	2.6
2.	10:55	1800	.5	71	105.	3.5	118.0	.85	2.5
3.	11:00	1800	1.0	71	99.	3.1	86.9	.80	2.5
4	11:05	1800	1.	72	98.	3.5	91.1	.90	2.5
5	11:10	1840	1.	73	98.	3.1	77.5	.90	2.0
6	11:15	1820	1.	74	100.	3.8	99.0	.80	2.0
7	11:20	1770	1.	72	101.	3.9	113.0	.90	2.0
8	11:25	1720	1.	72	100.	2.4	66.2	.80	2.0
9	11:30	1740	1.	72	99.	3.2	86.5	.80	2.0
10	11:35	1720	1.	73	98.	3.5	87.5	.80	2.0
11	11:40	1730	1.	72	99.	3.0	81.0	.88	2.2
12	11:45	1770	1.	72	99	3.5	94.6	.82	1.8
13	11:50	1750	7.	73	100	3.1	83.8	.85	1.7
TOTAL							1085.1		
AV.		1776	.9	72.1	100			.846	2.14

VACUUM CRANK CASE OIL. COEFFICIENT OF FRICTION .0779.

OIL TEST.

COMPARATIVE LUBRICATION.

TOTAL LOAD ON BEARING 275. LBS. PR SQ. IN. 20.

DATE MAY 3, 1907 TEST NO. 1

READ NO.	TIME	R.P.M.	OIL DROP PER MIN	WATER TEMP. IN.	WATER TEMP. OUT	WT WATER LBS.	B.T.U.	MOTOR K.W.	FRICTION PULL LBS
1.	2:25	1720	7	75	90			.80	2.
2	2:30	1740	7	72	91	5.0	95.0	.78	2.
3.	2:35	1860	8	79	95	4.0	64.1	.78	2.
4.	2:40	1860	8	81	95	4.5	63.1	.80	2.
5	2:45	1840	8	82	98	4.0	64.1	.77	2.
6	2:50	1840	8	82	100	4.2	75.6	.80	2.
7	2:55	1800	8	81	100	2.8	53.2	.77	2.
8	3:00	1800	7	81	100	5.1	97.0	.80	2.
9	3:05	1800	7	79	99	4.0	80.0	.80	2.
10	3:10	1830	7	78	99	3.9	81.9	.80	2.2
11	3:15	1850	7	77	99	4.1	90.4	.74	2.5
12	3:20	1800	8	77	98	3.4	71.4	.80	2.3
13	3:25	1800	8	77	98	4.0	84.0	.79	2.5
TOTAL							919.7		
AV		1810	7.54	78.7	97.2			.789	2.1
1	3:35	1830	7	77	96			.80	11.6
2	3:40	1860	7	77	98	4.0	84.0	.80	11.6
3	3:45	1790	7	77	99	3.7	81.4	.78	11.7
4	3:50	1830	7	78	99	4.0	84.0	.85	11.8
5	3:55	1760	7	78	100	3.6	79.2	.86	11.7
6	4:00	1740	7	77	101	3.3	79.2	.95	11.8
7	4:05	1770	7	77	101	4.0	96.2	.94	11.7
8	4:10	1820	7	77	102	3.6	90.0	.85	11.8
9	4:15	1800	7	78	98	3.0	60.0	.78	11.2
10	4:20	1830	7	77	102	4.0	100.0	.77	11.3
11	4:25	1840	7	77	102	4.2	105.0	.73	11.2
12	4:30	1810	7	77	100	3.4	78.3	.74	11.2
13	4:35	1800	7	77	99	4.7	103.5	.77	11.2
TOTAL							1040.8		
AV.		1810	7	77.3	99.7			.819	11.5

CAPITOL CYLINDER OIL. COEFFICIENT OF FRICTION .0772.

OIL TEST.

COMPARATIVE LUBRICATION.

TOTAL LOAD ON BEARING 275. LBS. PR. SQ. IN. 20.

DATE MAY 3, 1907 TEST NO. 2

READ. NO.	TIME	R.P.M.	OIL DROP PER MIN.	WATER TEMP. IN.	WATER TEMP. OUT	WT. WATER LBS.	B.T.U.	MOTOR K.W.	FRICTION PULL LBS
1.	4:45	1820	4	76	98			.78	11.2
2	4:50	1800	4	76	96	4.5	94.5	.76	11.4
3.	4:55	1786	4	76	96	4.4	86.5	.80	11.5
4.	5:00	1810	4	76	96	4.0	80.0	.82	11.7
5.	5:05	1820	4	76	92	6.2	111.0	.84	12.
6.	5:10	1820	4	76	90	8.0	120.0	.84	11.8
7.	5:15	1860	4	75	90	8.0	116.0	.78	11.4
8.	5:20	1860	4	75	88	5.0	77.0	.83	11.5
9.	5:25	1820	4	74	88	4.2	59.4	.80	11.5
10.	5:30	1820	4	72	87	5.2	75.0	.78	11.5
11.	5:35	1800	4	72	86	7.2	104.6	.78	11.3
12.	5:40	1836	2	76	84	6.0	48.0	.80	11.5
13.	5:45	1854	4	76	84	7.5	60.0	.80	11.2
TOTAL	5:50						1032.0		
AV.		1825	3.85	75	90.5			.80	11.42
1.	6:00	1828	4	69	90			.82	2.5
2.	6:05	1800	4	70	86	5.0	80.0	.84	2.5
3.	6:10	1820	4	70	87	4.6	78.2	.80	2.5
4	6:15	1820	4	70	88	5.3	95.6	.78	2.5
5	6:20	1814	4	70	88	5.0	90.0	.82	2.5
6	6:25	1816	4	70	88	4.8	84.6	.78	2.5
7	6:30	1818	4	71	89	6.0	108.0	.80	2.5
8	6:35	1800	4	71	89	3.7	56.6	.80	2.5
9	6:40	1820	4	71	89	5.8	104.2	.82	2.5
10	6:45	1800	4	71	90	4.4	83.6	.80	2.5
11	6:50	1820	4	71	89	4.5	81.0	.79	2.5
12	6:55	1800	4	71	89	4.8	86.5	.77	2.5
13	7:00	1790	4	71	89	4.5	81.0	.78	2.5
TOTAL							1029.3		
AV.		1810	4	70.5	88.5			.80	2.5

CAPITOL CYLINDER OIL. COEFFICIENT OF FRICTION .074.

OIL TEST.

COMPARATIVE LUBRICATION.

TOTAL LOAD ON BEARING 275. LBS. PR. SQ. IN. 20.

DATE May 3d 1907 TEST NO. 3

READ. NO.	TIME P.M.	R.P.M.	OIL DROP PER MIN.	WATER TEMP. IN.	WATER TEMP. OUT	WT. WATER LBS.	B.T.U.	MOTOR K.W.	FRICTION PULL LBS.
1.	7:55	1820	2	67	92			.8	2.5
2	8:00	1800	2	67	91	1.8	43.2	.8	2.5
3.	8:05	1830	2	67	100	2.0	66.0	.82	2.5
4.	8:10	1800	2	67	101	3.7	126.0	.82	2.4
5.	8:15	1830	2	69	90	5.0	120.0	.8	2.5
6.	8:20	1750	2	71	87	6.2	99.0	.8	2.5
7.	8:25	1790	2	73	87	6.2	86.8	.8	2.5
8.	8:30	1720	2	74	87	6.6	85.9	.78	2.4
9.	8:35	1730	2	74	88	5.5	77.0	.78	2.5
10	8:40	1720	2	73	88	5.7	75.0	.8	2.5
11.	8:45	1700	2	72	87	6.2	93.0	.8	2.5
12.	8:50	1710	2	71	86	5.5	82.5	.8	2.5
13	8:55	1800	2	70	86	6.0	96.2	.76	2.3
TOTAL							1050.6		
AV.		1780	2	70	89			.798	2.4

READ. NO.	TIME P.M.	R.P.M.	OIL DROP PER MIN.	WATER TEMP. IN.	WATER TEMP. OUT	WT. WATER LBS.	B.T.U.	MOTOR K.W.	FRICTION PULL LBS.
1	9:30	1700	2	66	82			.8	13.5
2.	9:35	1730	2	68	80	5.7	68.4	.82	13.2
3.	9:40	1700	2	68	82	5.0	70.0	.8	13.5
4	9:45	1800	2	69	83	5.9	81.3	.8	13.3
5	9:50	1740	2	71	85	6.0	84.0	.8	13.2
6	9:55	1750	2	72	86	5.7	79.9	.78	13.3
7	10:00	1700	2	72	86	5.0	70.0	.8	13.0
8	10:05	1780	2	71	87	6.3	100.6	.8	13.0
9	10:10	1770	2	71	86	6.0	90.0	.76	13.0
10	10:15	1820	2	70	85	5.5	82.5	.7	12.7
11	10:20	1820	2	69	84	5.2	78.0	.75	12.8
12	10:25	1800	2	69	84	5.5	82.5	.8	13.0
13	10:30	1780	2	69	84	5.5	82.5	.78	12.8
TOTAL							970.9		
AV.		1770	2	69.5	84.1			.784	13.2

CAPITOL CYLINDER OIL. COEFFICIENT OF FRICTION .0898.

OIL TEST.

COMPARATIVE LUBRICATION.

TOTAL LOAD ON BEARING 275. LBS. PR SQ. IN. 20.

DATE MAY 4, 1907 TEST NO. 4

READ. NO.	TIME	R.P.M.	OIL DROP PER MIN.	WATER TEMP. IN.	WATER TEMP. OUT	WT WATER LBS.	B.T.U.	MOTOR K.W.	FRICTION PULL LBS
1.	9:35	1720	1	67	91			.78	11.2
2.	9:40	1780	1	68	92	3.0	72.0	.78	11.1
3.	9:45	1780	1	69	94	2.5	62.5	.78	11.
4.	9:50	1800	1	70	94	2.9	69.6	.78	11.
5.	9:55	1780	1	70	94	2.6	62.5	.78	11.
6.	10:00	1820	1	71	95	2.3	55.3	.78	11.
7.	10:05	1780	1	71	96	3.1	77.5	.76	11.
8.	10:10	1720	1	72	96	3.0	72.0	.76	11.
9.	10:15	1740	1	72	97	3.6	90.0	.72	11.
10.	10:20	1800	1	72	98	1.5	24.0	.76	11.
11	10:25	1780	1	73	99	2.6	67.6	.70	11.
12.	10:30	1720	1	73	99	2.5	65.0	.76	11.
13	10:35	1700	1	72	99	2.7	73.0	.75	11.
TOTAL							791.0		
AV.		1760	1	70.8	95.7			.761	11.23
1.	10:45	1760	1	69	98			.82	3.7
2.	10:50	1710	1	70	112	1.7	71.4	.80	3.5
3.	10:55	1724	1	71	103	3.3	105.5	.81	3.5
4	11:00	1680	1	72	100	3.1	86.8	.86	3.6
5	11:05	1692	1	72	99	3.4	91.8	.82	3.5
6	11:10	1710	1	72	99	3.2	86.4	.82	3.5
7	11:15	1800	1	72	99	4.5	121.5	.82	3.5
8	11:20	1800	1	72	100	3.0	84.0	.82	3.5
9	11:25	1800	1	73	100	2.2	59.4	.82	3.4
10	11:30	1760	1	73	101	3.5	98.0	.80	3.4
11	11:35	1830	1	73	100	3.2	86.4	.83	3.4
12	11:40	1760	1	74	100	3.7	96.4	.86	3.4
13	11:45	1770	1	74	99	4.0	100.0	.86	3.5
TOTAL							1087.6		
AV.		1750	1	72.1	100.8			.826	3.49

CAPITOL CYLINDER OIL. COEFFICIENT OF FRICTION .0643.

OIL TEST.

COMPARATIVE LUBRICATION.

TOTAL LOAD ON BEARING 275. LBS. PR. SQ. IN. 20.

DATE MAY 4, 1907 TEST NO. 1

READ. NO.	TIME	R.P.M.	OIL DROP PER MIN.	WATER TEMP.		WT. WATER LBS.	B.T.U.	MOTOR K.W.	FRICTION PULL LBS.
				IN.	OUT				
1.	2:55	1730	7	66	86			.82	1.5
2.	3:00	1800	7	69	84	3.7	55.5	.80	1.5
3.	3:05	1800	7	70	87	3.2	54.5	.80	1.5
4.	3:10	1760	8	71	89	4.0	72.0	.78	1.6
5.	3:15	1720	8	72	90	4.4	79.2	.76	1.6
6.	3:20	1800	8	74	92	3.8	68.4	.78	1.6
7.	3:25	1820	7	76	93	4.0	68.0	.80	1.7
8.	3:30	1800	7	78	95	3.9	66.4	.80	1.7
9.	3:35	1812	8	80	97	5.0	85.0	.78	1.8
10.	3:40	1760	8	79	99	3.0	60.0	.76	1.7
11.	3:45	1770	7	77	100	3.4	78.2	.80	1.8
12.	3:50	1800	7	74	99	4.9	122.5	.80	1.7
13.	3:55	1770	7	73	98	2.3	57.5	.80	1.8
TOTAL							867.2		
AV.		1780	7.38	73.5	93			.79	1.65
1.	4:00	1800	7	71	97			.82	11.7
2.	4:05	1800	7	71	96	3.5	87.5	.80	11.5
3.	4:10	1800	7	71	96	3.4	85.0	.80	11.5
4	4:15	1800	7	71	96	3.5	87.5	.80	11.5
5	4:20	1810	7	71	96	3.2	80.0	.78	11.5
6	4:25	1800	7	71	96	3.5	87.5	.78	11.5
7	4:30	1790	7	71	96	3.1	77.5	.78	11.4
8	4:35	1820	7	71	95	2.5	60.0	.76	11.4
9	4:40	1796	7	71	95	4.1	98.5	.77	11.4
10	4:45	1800	7	70	95	3.5	87.5	.78	11.3
11	4:50	1790	7	70	95	2.8	70.0	.76	11.4
12	4:55	1800	7	70	95	2.1	52.5	.76	11.3
13	5:00	1790	7	70	94	4.2	101.0	.76	11.2
TOTAL							974.5		
AV.		1795	7	70.7	95.54			.781	11.43

WATT CYLINDER OIL. COEFFICIENT OF FRICTION .081

Oil Test.

Comparative Lubrication.

Total Load on Bearing 275. Lbs. pr. Sq. In. 20.

Date May 6, 1907 Test No. 2

Read. No.	Time	R.P.M.	Oil Drop Per Min.	Water Temp.		Wt. Water Lbs.	B.T.U.	Motor K.W.	Friction Pull Lbs.
				In.	Out				
1.	10:25	1700	4	67	89			.98	1.5
2.	10:30	1680	3	68	89	4.0	84.0	.8	1.5
3.	10:35	1786	4	68	93	1.8	45.0	.8	1.5
4.	10:40	1764	4	69	95	2.9	76.4	.8	1.5
5.	10:45	1680	4	69	96	2.8	75.6	.8	1.5
6.	10:50	1660	4	70	97	2.5	67.5	.79	1.5
7.	10:55	1690	4	71	99	2.6	72.8	.8	1.6
8.	11:00	1700	4	71	101	2.7	81.0	.79	1.6
9.	11:05	1690	4	72	102	3.4	102.0	.78	1.7
10.	11:10	1700	4	70	90	7.0	140.0	.80	1.5
11.	11:15	1710	4	73	99	3.0	78.0	.8	1.5
12.	11:20	1710	4	73	101	3.9	109.0	.8	1.5
13.	11:25	1750	4	73	103	1.1	33.0	.8	1.5
Total	/						964.3		
Av.		1710	4	70.1	96.5			.81	1.53
1.	11:30	1730	4	72	97			.86	10.5
2.	11:35	1790	4	73	96	4.5	103.5	.82	10.4
3.	11:40	1840	4	73	96	4.2	96.6	.80	10.5
4	11:45	1840	4	73	96	4.2	96.6	.80	10.2
5	11:50	1900	4	72	97	3.5	87.6	.78	10.3
6	11:55	1920	4	72	97	3.7	92.6	.78	10.2
7	12:00	1880	4	73	97	3.0	62.0	.80	10.5
8	12:05	1790	4	73	97	3.7	88.9	.80	10.3
9	12:10	1820	4	72	97	3.0	75.0	.77	10.2
10	12:15	1780	4	72	96	4.0	96.0	.75	10.3
11	12:20	1800	4	72	96	4.0	96.0	.80	10.5
12	12:25	1820	4	72	96	2.1	50.4	.80	10.2
13	12:30	1850	4	72	96	3.4	81.6	.80	10.5
Total							1026.8		
Av.		1828	4	724	96.5			.795	10.35

Watt Cylinder Oil. Coefficient of Friction .0733.

OIL TEST.

COMPARATIVE LUBRICATION.

TOTAL LOAD ON BEARING 275. LBS. PR. SQ. IN. 20.

DATE MAY 6, 1907 TEST NO. 3

READ. NO.	TIME	R.P.M.	OIL DROP PER MIN.	WATER TEMP. IN.	WATER TEMP. OUT	WT. WATER LBS.	B.T.U.	MOTOR K.W.	FRICTION PULL LBS
1.	1:05	1800	2	76	87			.90	2.
2.	1:10	1800	2	76	91	5.2	78.0	.88	2.5
3.	1:15	1820	2	77	94	4.1	69.8	.84	2.5
4.	1:20	1840	2	77	97	4.1	82.0	.86	2.5
5.	1:25	1860	2	79	94	3.6	54.0	.84	2.7
6.	1:30	1836	2	80	101	3.9	82.0	.80	2.8
7.	1:35	1810	2	81	103	3.7	81.4	.82	2.7
8	1:40	1820	2	82	100	4.9	88.2	.81	2.8
9.	1:45	1800	2	81	97	5.0	80.0	.80	2.7
10.	1:50	1800	2	79	96	6.4	108.9	.82	2.8
11.	1:55	1810	2	78	95	5.0	85.0	.84	2.7
12.	2:00	1810	2	78	94	6.3	98.5	.84	2.8
13	2:05	1843	2	77	94	6.0	102.0	.84	2.8
TOTAL							1009.8		
AV.		1820	2	79	95.8			.836	2.64
1.	2:25	1760	2	76	96			.8	12.
2.	2:30	1900	2	75	96	3.7	77.8	.8	12.
3.	2:35	1820	2	76	96	6.3	126.0	.78	12.
4	2:40	1800	2	76	96	3.0	60.0	.78	12.
5	2:45	1800	2	76	96	3.5	70.0	.8	12.
6	2:50	1760	2	77	96	5.4	102.7	.8	12.
7	2:55	1800	2	77	97	4.0	80.0	.82	11.9
8	3:00	1800	2	77	98	5.2	109.1	.8	12.
9	3:05	1774	2	77	98	3.0	63.0	.8	11.7
10	3:10	1824	2	77	98	4.5	94.5	.82	11.8
11	3:15	1894	2	77	98	4.1	86.1	.8	11.7
12	3:20	1850	2	76	98	4.0	88.0	.8	11.8
13	3:25	1860	2	76	97	4.1	86.1	.8	11.7
TOTAL							1043.3		
AV.		1820	2	76.3	97			.815	11.9

WATT CYLINDER OIL. COEFFICIENT OF FRICTION .077.

OIL TEST.

COMPARATIVE LUBRICATION.

TOTAL LOAD ON BEARING 275. LBS. PR. SQ. IN. 20.

DATE MAY 6 1907 TEST NO. 4.

READ. NO.	TIME	R.P.M.	OIL DROP PER MIN.	WATER TEMP. IN.	WATER TEMP. OUT	WT. WATER LBS.	B.T.U.	MOTOR K.W.	FRICTION PULL LBS.
1.	3:40	1900	1	76	98			.8	10.7
2.	3:45	1830	1	72	92	7.8	156.0	.83	10.8
3.	3:50	1780	1	76	96	4.0	80.0	.84	10.7
4.	3:55	1750	1	76	98	3.5	77.0	.8	10.8
5.	4:00	1760	1	76	99	4.2	96.8	.8	10.8
6.	4:05	1760	1	76	100	2.4	57.6	.84	11.0
7.	4:10	1736	1	76	101	3.6	90.0	.82	10.9
8.	4:15	1800	1	75	100	3.3	82.5	.8	10.6
9.	4:20	1800	1	75	100	3.8	95.1	.82	10.7
10.	4:25	1817	1	75	100	3.5	87.5	.78	10.6
11.	4:30	1794	1	75	100	3.4	85.0	.84	11.0
12.	4:35	1740	1	75	100	3.0	75.0	.83	10.5
13.	4:40	1840	1	75	100	4.0	100.0	.78	10.4
TOTAL							1082.5		
AV.		1790	1	75.1	99			.814	10.73
1.	4:45	1808	1	75	100			.83	4.
2.	4:50	1740	1	75	100	4.0	100.0	.86	4.
3.	4:55	1860	1	76	100	4.0	96.0	.82	4.
4	5:00	1760	1	76	97	3.0	63.0	.83	4.
5	5:05	1780	1	76	103	3.0	81.0	.83	4.
6	5:10	1816	1	76	104	3.5	98.0	.81	4.
7	5:15	1850	1	76	105	3.0	87.0	.84	4.
8	5:20	1786	1	76	105	2.5	72.5	.82	4.
9	5:25	1804	1	76	100	3.5	84.0	.83	4.
10	5:30	1760	1	76	105	3.0	87.1	.83	4.
11	5:35	1760	1	76	105	4.0	116.0	.85	4.
12	5:40	1830	1	76	105	3.5	101.5	.85	4.
13	5:45	1818	1	76	106	3.0	90.0	.86	4.
TOTAL							1076.1		
AV.		1797	1	75.85	102.5			.835	4.

WATT CYLINDER OIL. COEFFICIENT OF FRICTION .0558.

OIL TEST.

COMPARATIVE LUBRICATION.

TOTAL LOAD ON BEARING 275. LBS. PR. SQ. IN. 20.

DATE MAY 21, 1907 TEST NO. 1

READ. NO.	TIME	R.P.M.	OIL DROP PER MIN.	WATER TEMP. IN.	WATER TEMP. OUT	WT. WATER LBS.	B.T.U.	MOTOR K.W.	FRICTION PULL LBS.
1.	9:40	1740	6	65	85			.82	10.2
2	9:45	1755	6	66	82	3.5	56.0	.84	10.8
3.	9:50	1800	6	66	82	3.8	60.9	.83	10.8
4.	9:55	1800	7	66	85	3.0	57.0	.80	10.8
5.	10:00	1800	6	67	88	3.1	65.2	.79	10.8
6.	10:05	1800	7	67	92	2.5	62.5	.78	10.5
7.	10:10	1726	6	67	92	2.6	65.0	.76	10.5
8.	10:15	1804	7	67	95	3.2	89.6	.76	10.5
9.	10:20	1812	6	67	97	3.0	90.0	.76	10.5
10	10:25	1785	6	68	96	4.5	126.1	.80	10.7
11	10:30	1782	6	68	94	2.5	65.0	.78	10.5
12.	10:35	1800	6	67	96	2.5	72.6	.76	10.4
13	10:40	1800	6	67	96	1.4	40.7	.73	10.5
TOTAL							855.6		
AV.		1790	6.25	66.8	90.6			.787	10.58
1	10:45	1750	7	67	96			.83	3.4
2.	10:50	1800	6	68	93	3.9	97.8	.82	3.6
3.	10:55	1740	6	68	92	4.0	96.0	.80	3.5
4	11:00	1760	6	68	88	5.4	108.0	.82	3.5
5	11:05	1800	6	68	92	4.7	112.9	.80	3.5
6	11:10	1800	6	68	93	3.6	90.0	.80	3.5
7	11:15	1760	6	68	93	2.6	65.0	.80	3.5
8	11:20	1800	6	68	97	2.8	81.2	.86	3.5
9	11:25	1720	6	69	98	2.8	81.2	.78	3.6
10	11:30	1770	6	69	101	2.5	80.1	.78	3.5
11	11:35	1740	6	69	98	2.3	66.7	.78	3.5
12	11:40	1730	6	69	96	3.0	81.0	.80	3.5
13	11:45	1740	6	69	92	2.7	62.1	.76	3.5
TOTAL							1040.0		
AV.		1760	6.1	68.3	94.5			.804	3.508

EXTRA CRANK CASE OIL. COEFFICIENT OF FRICTION .058.

OIL TEST.

COMPARATIVE LUBRICATION.

TOTAL LOAD ON BEARING 275. LBS. PR SQ. IN. 20.

DATE MAY 21, 1907 TEST NO. 2

READ NO.	TIME	R.P.M.	OIL DROP PER MIN.	WATER TEMP. IN.	WATER TEMP. OUT	WT WATER LBS.	B.T.U.	MOTOR K.W.	FRICTION PULL LBS
1.	11:55	1800	4	70	109			.82	3.5
2.	12:00	1750	4	70	109	1.8	52.2	.80	3.5
3.	12:05	1730	4	70	96	4.6	119.5	.80	3.5
4.	12:10	1740	4	71	96	3.6	90.1	.86	3.5
5	12:15	1860	4	65	80	13.7	205.8	.86	3.5
6	12:20	1750	4	67	80	7.8	101.5	.86	3.5
7	12:25	1870	4	63	88	2.2	55.1	.82	3.5
8	12:30	1800	4	62	79	7.7	130.9	.83	3.5
9	12:35	1800	4	61	80	6.8	129.0	.80	3.5
10	12:40	1782	4	62	82	4.9	98.0	.81	3.5
11	12:45	1812	4	62	85	4.4	101.0	.80	3.5
12	12:50	1800	4	62	88	3.3	85.9	.80	3.5
13	12:55	1860	4	63	89	3.8	98.9	.80	3.5
TOTAL							1537.9		
AV.		1795	4	65.2	89.5			.82	3.5
1	1:05	1770	4	60	74			.85	11.2
2.	1:10	1810	4	61	78	6.2	105.4	.82	11.0
3.	1:15	1780	4	62	85	4.0	102.0	.80	11.0
4	1:20	1776	4	62	71	7.7	69.3	.81	11.0
5	1:25	1810	4	60	74	11.5	161.0	.81	11.0
6	1:30	1770	4	61	74	10.3	134.0	.80	11.0
7	1:35	1780	4	61	74	8.4	109.1	.80	11.0
8	1:40	1810	4	61	78	8.0	136.0	.78	10.7
9	1:45	1800	4	62	80	4.0	72.0	.78	10.8
10	1:50	1784	4	62	83	4.7	98.8	.78	10.6
11	1:55	1730	4	63	85	3.6	79.3	.80	10.6
12	2:00	1780	4	63	80	7.0	119.0	.80	10.7
13	2:05	1760	4	62	80	5.5	99.1	.79	10.7
TOTAL							1374.0		
AV.		1780	4	61.5	78.1			.805	10.87

EXTRA CRANK CASE OIL. COEFFICIENT OF FRICTION .0611

OIL TEST.

COMPARATIVE LUBRICATION.

TOTAL LOAD ON BEARING 275. LBS. PR SQ. IN. 20.

DATE MAY 21, 1907 TEST NO. 3

READ NO.	TIME	R.P.M.	OIL DROP PER MIN.	WATER TEMP. IN.	WATER TEMP. OUT	WT WATER LBS.	B.T.U.	MOTOR K.W.	FRICTION PULL LBS
1.	2:15	1740	2	62	79			.78	10.9
2.	2:20	1770	2	62	80	8.5	153.0	.78	10.7
3.	2:25	1800	2	62	86	3.2	77.0	.78	10.8
4.	2:30	1742	2	63	90	1.8	48.6	.77	10.6
5.	2:35	1800	2	63	83	6.7	134.0	.78	10.7
6.	2:40	1780	2	63	81	6.0	108.0	.80	10.8
7.	2:45	1800	2	62	81	6.0	114.0	.78	10.7
8	2:50	1800	2	62	82	5.0	100.0	.78	10.8
9.	2:55	1800	2	62	82	5.5	110.0	.78	10.6
10.	3:00	1764	2	63	82	4.6	87.5	.76	10.5
11	3:05	1813	2	63	81	5.5	99.0	.76	10.5
12	3:10	1760	2	63	81	4.8	86.4	.78	10.5
13	3:15	1777	2	63	81	5.0	90.0	.79	10.7
TOTAL							1252.5		
AV.		1710	2	62.3	82			.78	10.6
1	3:20	1800	2	62	81			.84	4.1
2.	3:25	1778	2	63	82	5.3	100.5	.82	4.0
3	3:30	1740	2	62	83	6.0	126.0	.85	4.0
4	3:35	1856	2	62	82	6.6	132.0	.82	3.9
5	3:40	1748	2	62	81	5.3	100.5	.84	3.7
6	3:45	1744	2	62	82	5.0	100.0	.85	3.9
7	3:50	1840	2	62	83	5.5	115.4	.85	3.7
8	3:55	1740	2	62	85	4.4	101.2	.84	3.8
9	4:00	1785	2	63	86	4.4	101.2	.85	3.7
10	4:05	1740	2	63	87	4.4	105.5	.85	3.8
11	4:10	1750	2	63	89	3.8	144.5	.84	3.7
12	4:15	1733	2	64	92	3.0	84.0	.85	3.8
13	4:20	1800	2	64	94	3.2	96.0	.83	3.8
TOTAL							1177.8		
AV.		1780	2	62.8	84			.84	3.76

EXTRA CRANK CASE OIL COEFFICIENT OF FRICTION .0568

OIL TEST.

COMPARATIVE LUBRICATION.

TOTAL LOAD ON BEARING 275. LBS. PR. SQ. IN. 20.

DATE MAY 22, 1907 TEST NO. 4

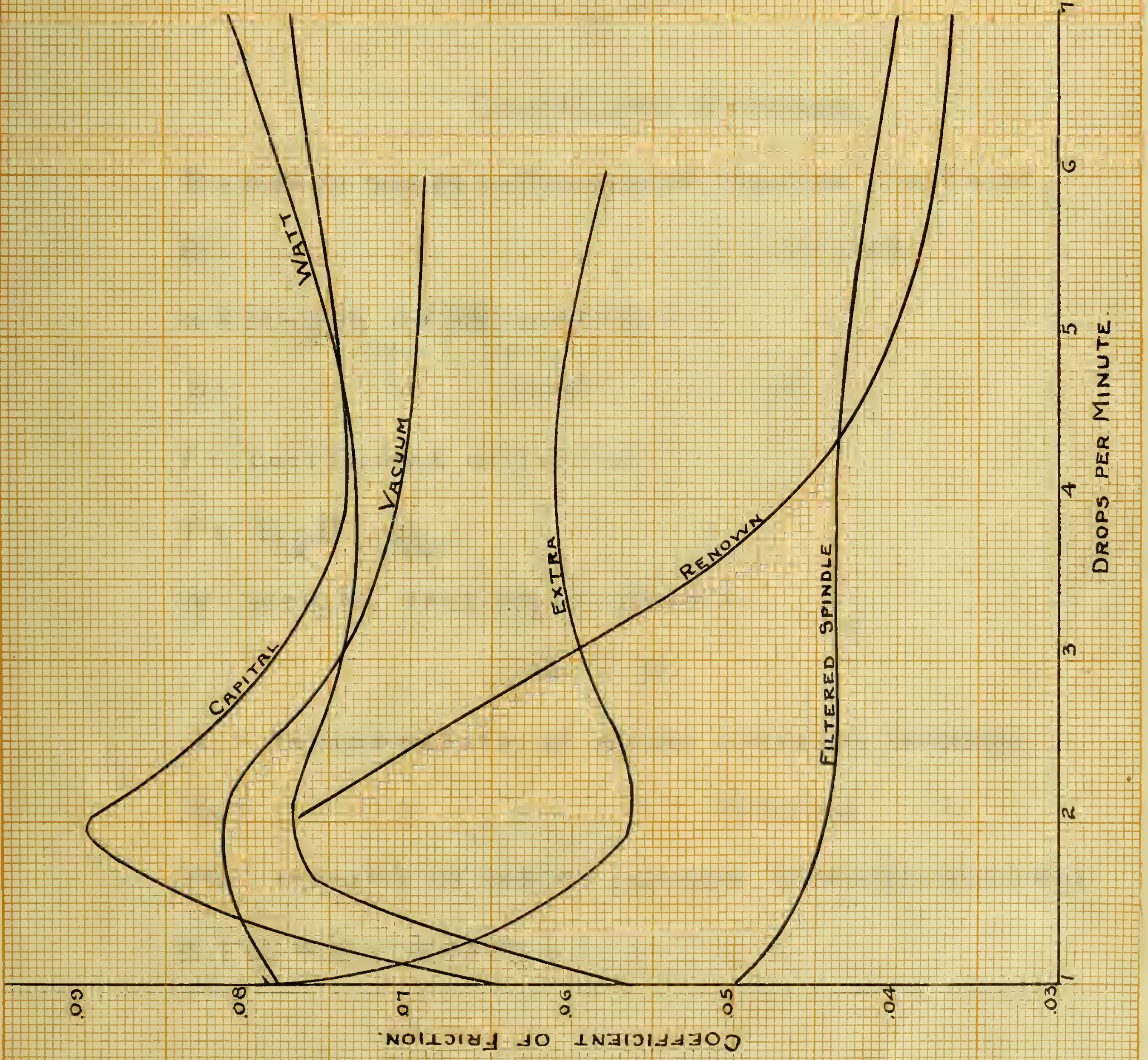
READ. NO.	TIME	R.P.M.	OIL DROP PER MIN.	WATER TEMP. IN.	WATER TEMP. OUT	WT. WATER LBS.	B.T.U.	MOTOR K.W.	FRICTION PULL LBS.
1.	8:40	1785	1	65	93			.96	1.4
2.	8:45	1704	1	64	91	5.0	135.0	.80	1.5
3.	8:50	1700	1	63	87	5.0	120.0	.82	1.5
4.	8:55	1720	1	63	87	5.5	134.0	.85	1.5
5.	9:00	1785	1	63	86	3.9	89.9	.83	1.4
6.	9:05	1765	1	64	87	5.2	119.5	.83	1.5
7.	9:10	1740	1	64	87	4.5	103.5	.85	1.5
8.	9:15	1712	1	64	88	6.4	153.5	.88	1.5
9.	9:20	1800	1	64	88	3.1	74.5	.88	1.4
10	9:25	1706	1	64	88	3.5	84.0	.85	1.4
11	9:30	1770	1	64	88	5.0	120.0	.85	1.5
12.	9:35	1700	1	64	89	3.3	82.5	.88	1.5
13	9:40	1740	1	64	90	5.2	135.0	.90	1.5
TOTAL							1351.4		
AV.		1740	1	63.8	88.2			.86	1.46
1	9:50	1722	1	65.	90			.88	11.5
2.	9:55	1800	1	65	94	3.2	92.9	.88	11.5
3.	10:00	1732	1	66	97	3.2	99.1	.80	11.0
4	10:05	1708	1	66	97	3.0	93.0	.80	11.0
5	10:10	1680	1	66	98	3.5	112.0	.80	10.9
6	10:15	1737	1	67	98	3.6	111.5	.80	11.0
7	10:20	1747	1	68	99	3.0	93.0	.80	10.9
8	10:25	1733	1	68	99	2.9	90.0	.80	11.0
9	10:30	1783	1	69	99	2.3	69.0	.80	11.0
10	10:35	1700	1	69	100	3.0	93.0	.80	10.9
11	10:40	1767	1	69	100	3.0	93.0	.80	10.8
12	10:45	1736	1	69	101	2.6	83.2	.78	10.7
13	10:50	1764	1	69	100	2.8	86.9	.78	10.7
TOTAL							1116.6		
AV.		1740	1	67.4	97.6			.81	10.99

EXTRA CRANK CASE OIL. COEFFICIENT OF FRICTION .079

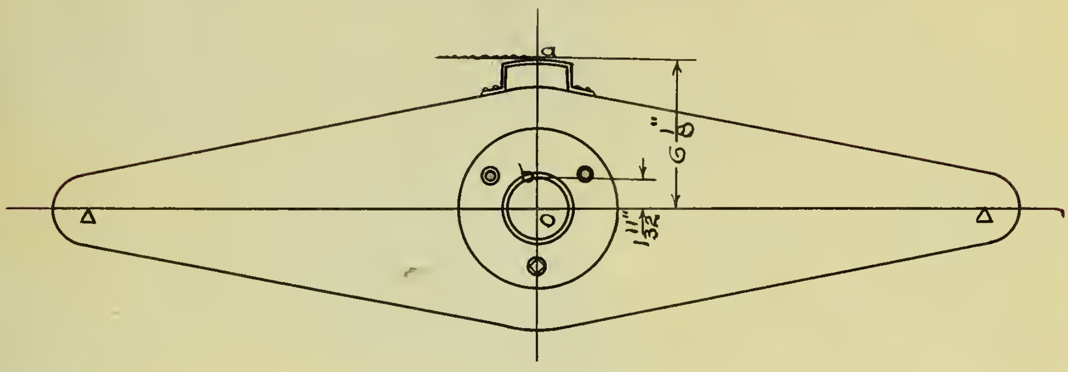
Oil Test

Comparative Lubrication

Friction Curves



Explanation of Method Employed in Calculating Results.



Coefficient of Friction.

P_1 = pull on scales when spindle revolves clockwise.

P_2 = " " " " " is reversed.

a = length oa or scale arm.

b = " ob " load " .

f = coefficient of friction.

$$f = \frac{P_1 - P_2}{2} \; \frac{a}{bW}$$

W = weight resting on spindle.

B. T. U.

t_1 = temperature of water entering housing.

t_2 = " " " leaving " .

W_w = weight of water passed through housing.

$$B.T.U. = (t_2 - t_1) W_w.$$

CONCLUSIONS

All tests were run with the same total loads on the bearing, namely, 275 pounds, or 20 pounds per square inch projected area. All readings shown on the sheet were taken direct from the apparatus on the machine, except the B. t. u. which were calculated from the rise in temperature and the weight of water passed through the housing of the bearing. The friction column does not give the actual pull at the surface of the bearing but the pull as given by the scales. The scales and thermometers were tested at the beginning of the trial and found to be correct.

The curves of friction drawn for the Renown and the Filtered Spindle Engine Oil show that the Renown Oil gives a slightly lower coefficient of friction than the Filtered Spindle Oil when the bearing is flooded but that the Filtered Spindle Oil is much superior under light oil feeds. A supply of two drops or less are not sufficient to lubricate the bearing. The heat generated when using the Renown Oil under light feeds was more than when using the same amount of Filtered Spindle Oil. Although the coefficient of friction as given by the Renown oil is less than that given by the Filtered Spindle Oil when running with a flooded bearing, the general behavior of the oil seems to show that the Filtered Spindle is superior to the Renown.

When the bearing was lubricated with cylinder oil it was found that the lowest doefficient of friction was obtained with the Watt oil and that with a drop of one per minute. The only test in which the product of the Standard Oil Company was superior

to that of the Viscosity Oil Company, was when the oil was being fed at the faster speed. Under all conditions except this one the product of the Viscosity Oil Company was found to be superior to that of the Standard Oil Company. The coefficient of friction decreases steadily as the cylinder oil was being fed more and more sparingly, but in each case the coefficient was higher than with engine oil. This is due to the fact that the heavier oils are too thick and viscous for lubricating purposes on bearings. These tests also show that when a heavy oil has to be used for lubricating purposes they should be used very sparingly as the friction is less then than when they are fed more rapidly.